CHAPTER 16

POWER SYSTEMS

This chapter provides information relative to the various types of power sources and systems commonly employed at Naval Shore Stations. Alternating current (AC), direct current (DC), switching devices, batteries and wiring methods are some of the subjects covered.

16.1 BATTERIES

Both dry-cell and wet-cell storage batteries are used as a source of power for certain communications equipment. These DC supplies are sometimes used in combination with other sources of power, or are retained for emergency use. Portable storage batteries provide a compact portable source of DC for operation of various radio receivers and transmitters. These batteries are also used for ignition systems and for cranking gasoline and diesel engines on engine-generator sets rated up to 50 kW.

16.1.1 Lead-Acid Type

The most commonly used wet-cell battery is the lead-acid type. The average voltage per cell on discharge is between 2.0 and 1.95 volts. The average voltage necessary to charge lead acid portable batteries is 2.36 volts per cell. The sulfuric acid electrolyte should have a specific gravity (sg) of about 1.285 to 1.300 at full charge; however, this may vary downward to about 1.265 in certain instances.

a. Dry-Shipped Battery. Batteries are shipped filled and charged, dry and charged, or dry and uncharged. If shipped filled and charged, a battery is ready for service, but has already begun to deteriorate; therefore, batteries which are not intended for immediate service are usually shipped dry, either charged or uncharged, and must be serviced prior to installation.

o Initial Charge of Dry-Uncharged Battery

STEP 1. Fill cells with acid of the specific gravity indicated in the manufacturer's instructions. Add the electrolyte until its level reaches the bottom of the filling level mark; where there is no mark, fill to three-eighths of an inch above the separators.

STEP 2. Cool battery artificially, or allow to stand at least 12 hours (filling with electrolyte will have caused it to become heated); do not allow to stand for more than 24 hours before beginning the charge.

STEP 3. Restore the level of the electrolyte (which will have dropped because of the soaking into the plates and separators) to that of step 1; use acid of the same specific gravity as used initially.

STEP 4. Charge, use three-fourths of the finish rate of the battery, as obtained from the table 16-1.

o Initial Fill of Dry-Charged Battery. Fill the cells with electrolyte and allow battery to stand for 24 hours.

b. Preparing Electrolyte

(1) Safety and first aid precautions in reference to the preparation of electrolytes may be found in paragraph 1.14.

(2) Technique for Preparing Electrolyte

STEP 1. Determine quantity and specific gravity of desired electrolyte and specific gravity of acid to be used.

STEP 2. From table 16-2 determine ratio of water to add. Use volume or weight columns to agree with quantity units of step 1.

STEP 3. Add 1.00 to the number obtained in step 2.

STEP 4. Divide the amount of electrolyte desired by the number obtained in step 3 to determine quantity of acid necessary.

STEP 5. Multiply the water-acid ratio (obtained in step 2) by the quantity of acid (obtained in step 4) to determine the quantity of water required.

Example

Prepare two quarts of electrolyte with a specific gravity of 1.21; use an acid with a specific gravity of 1.835 (step 1).

From table 16-2, volume ratio of water-to-acid = 4.00 (step 2);

$4.00 + 1.00 = 5.00$ (step 3);

$\text{Acid} = \frac{2.00}{5.00} = 0.40 \text{ qt}$ (step 4);

$\text{Water} = 0.400 \times 4.00 = 1.60 \text{ qt}$ (step 5).

STEP 6. Pour required amount of distilled water of known purity (step 5) into a rubber- or lead-lined container.

STEP 7. Slowly add the required amount of acid (step 4) to the water; stir continuously to prevent the acid from settling to the bottom of the container.

c. Determining State of Charge. The state of charge of a lead-acid storage battery may be determined by measuring the specific gravity of the electrolyte; however, this should not be done immediately after adding water as a false reading will result. Measure with a hydrometer (see figure 16-1) and thermometer and add the temperature correction from table 16-3 to the hydrometer reading to obtain corrected specific gravity and state of charge. A fully charged battery has a specific gravity of 1.285; a fully discharged battery reads 1.150.

16.1.2 Nickel-Cadmium Type

The average voltage necessary to charge nickel-cadmium batteries is 1.56 volts per cell. The caustic-potash electrolyte must have a specific gravity of about 1.290, which remains practically constant even if the battery is not fully charged. The nickel-cadmium battery is more suitable for use at low temperatures than the lead-acid battery. The following paragraphs discuss the electrolyte and the discharging of the battery. When work is required on nickel-cadmium batteries, the maintenance manual must be consulted; maintenance methods differ greatly from those used on lead-acid batteries. Also keep in mind that the voltages, specific gravity reading, and charging times and rates vary from battery to battery; the values mentioned below are intended only as examples.

a. Electrolyte. The electrolyte of a nickel-cadmium battery is a solution of 70-percent distilled water and 30-percent potassium hydroxide (specific gravity is 1.3). Since the electrolyte does not enter into a chemical reaction with either the positive or negative plate, but merely acts as a conductor between the two, the specific gravity remains relatively constant over the range of fully charged to fully discharged. Therefore, the specific gravity cannot be used as an index to the level of charge.

The electrolyte, however, is absorbed into the plates during the discharge cycle and expelled during the charge cycle. For this reason, water should not be added to a partially discharged battery since it may overflow when charged.

The electrolyte level shall be adjusted as follows:

STEP 1. Remove vent caps.

STEP 2. Fill with distilled water of known purity to a level of from 1/16 to 1/8 inch above the plates.

STEP 3. Replace and securely tighten vent caps.

b. Discharging the Battery. It is desirable to discharge a battery for several reasons; for example, to replace or rebalance cells.

STEP 1. Discharge through equipment or a resistor bank at a rate not exceeding the ampere-hour (AH) rating; i.e., a 40-AH battery should not be discharged at a rate exceeding 40 amperes per hour.

Example

A 40-AH battery would be discharged in two hours at a 20-ampere rate.

STEP 2. When the battery appears to be discharged and current no longer flows, decrease the resistance so that the battery discharges at one-half the ampere-hour rating.

STEP 3. When the terminal voltage of the battery is less than 10 percent of its rated voltage, apply shorting bars to the individual cells.

NOTE

It is important that the shorting bars be placed in position while the resistance is still connected to the battery or immediately upon its removal; allowing the battery to stand unloaded will permit partial charge.

16.1.3 Methods of Charging Batteries

Batteries can be charged by any of several methods depending on equipment and time available. Many installations have provisions for charging batteries in service; additional charging is required only under unusual conditions.

a. Floating Charge. When a battery is standing idle or used for stand-by service where current demand is low, it may be put on a floating or trickle charge. This is accomplished by maintaining a constant voltage across the battery equal to 2.15 volts per cell for a lead-acid battery and 1.40 volts per cell for a nickel-cadmium battery. A fully charged battery will draw about 0.001 ampere per ampere-hour of capacity when floated in this manner.

b. Normal Charge. The normal charge (slow charge) is the most desirable method of bringing a battery to full charge.

o Lead-Acid Battery

STEP 1. Add distilled water to bring the electolyte to the proper level.

STEP 2. Ensure that the vent plug is in place and the vent hole is clear.

STEP 3. Set controls of charging-current source for minimum charging rate.

STEP 4. Turn off charging-current source.

CAUTION

Never connect or disconnect batteries with power applied to the battery-charging source.

STEP 5. Connect positive wire from source of charging current to positive terminal of storage battery; connect the negative wire to the negative terminal.

STEP 6. Connect voltage jumper leads if provision is made for them on the charging panel. Make sure all connections are tight and have an ample, clean surface.

STEP 7. Ascertain proper charging rate to be used from battery nameplate or table 16-1.

STEP 8. Apply power to charging-current source and adjust for the proper charging rate, as indicated on the ammeter. As the voltage of the battery rises, it will be necessary to make adjustments in order to maintain this rate.

STEP 9. Take voltage, temperature, and specific gravity readings of pilot cells hourly while battery is on charge. As the battery approaches the charged condition, watch temperature readings of the electrolyte. The temperature shall not be allowed to exceed 52°C (125°F).

STEP 10. When the battery begins to gas freely, or when the voltage reaches 2.35 volts per cell, decrease the charging rate to the finish rate. Never use a higher finish rate than that given in table 16-1.

- Nickel-Cadmium Battery

STEP 1. Ascertain the correct voltage, charging time and rate, etc., from the manual for the specific battery.

CAUTION

A nickel-cadmium battery absorbs electrolyte into the plates during discharge; charging will therefore raise the electrolyte level. For this reason, water should not be added prior to charging unless absolutely necessary.

STEP 2. Check electrolyte level and add distilled water if necessary.

STEP 3. See that vent caps are in place and unobstructed.

NOTE

Some batteries are shipped with solid vent plugs to prevent loss of fluid during transit. These must be replaced with the proper plugs prior to charging the battery.

STEP 4. Set controls of charging-current source for a minimum charging rate.

STEP 5. Connect positive wire from source of charging current to positive terminal of storage battery; connect negative wire to the negative terminal.

STEP 6. Connect voltage jumper leads, if provision is made for them on the charging panel. Make sure connections are tight and have an ample, clean surface.

STEP 7. Ascertain proper charging rate to be used from battery nameplate or table 16-4.

STEP 8. Apply power to charging current source and adjust for the proper charging rate as indicated on the ammeter. As the voltage of the battery rises, it will be necessary to make adjustments in order to maintain this rate.

STEP 9. Take voltage measurements hourly while the battery is on charge. As the battery approaches the charged condition, a sharp rise in voltage will be noted. The battery should remain on charge for an additional two hours after this rise occurs.

c. Emergency Charge. A battery is given an emergency charge to put the maximum energy into the battery in a minimum of time.

o Lead-Acid Battery

STEP 1. Accomplish steps 1 through 6 as in normal charge procedure.

STEP 2. Apply power to the charging-current source and adjust the charging current to a rate high enough to bring the voltage up to about 2.40 volts per cell.

STEP 3. When gassing starts, lower the voltage until only a slight gassing of the cells occurs. Maintain this charging voltage.

STEP 4. Maintain this voltage with a steadily decreasing current until the finish rate (table 16-1) is reached.

STEP 5. Maintain finishing current until charge is complete.

o Nickel-Cadmium Battery

STEP 1. Accomplish steps 1 through 6 as in the normal procedure.

STEP 2. Apply power to the charging-current source and adjust charging current to a rate equal to its capacity rating; thus, charge a 40-AH battery at 40 amperes.

o Fast Charge. The fast charge, also called a quick or hot-shot charge, is the method often used by garages or service stations to bring a battery up to about 80 percent of full charge in a short time.

However, the emergency charge method is not recommended. The high rates of charge cause rapid gassing which may result in flooding the electrolyte out of the battery; high temperatures result that will damage the battery if this method is repeated frequently. Rapid rates of gassing will cause the positive active material to be broken from the positive plates of lead-acid batteries; repeated use of these high rates of charge will peroxidize the positive grids of lead-acid batteries.

16.1.4 Battery Installation Techniques

a. Making Connections

STEP 1. Clean terminal posts of all grease and oil by wiping with a solvent-dampened rag.

STEP 2. Remove electrolyte film from terminals by wiping with a rag moistened in a neutralizing solution of fresh water, ammonia, or baking soda for lead-acid types; or a 5-percent solution of acetic acid for nickel-cadmium batteries.

STEP 3. Remove oxidation from contact surfaces with a wire brush or fine sandpaper. Use extreme care to prevent the wire brush from shorting cell terminals.

STEP 4. Make the connection; tighten bolts securely.

STEP 5. Cover all exposed metal of connector with a film of petroleum jelly or cup grease to prevent corrosion.

b. Compartment Preparation. Compartment preparation should be accomplished prior to installation of a battery.

STEP 1. With running water, wash out all loose corrosion and electrolyte (if a battery has been previously installed in the compartment).

STEP 2. Neutralize the compartment with ammonia or baking soda solution for lead-acid batteries; use a 5-percent acetic-acid solution for nickel-cadmium batteries.

Step 3. Flush out neutralizing solution with cold running water.

STEP 4. Allow to dry.

STEP 5. Paint compartment with electrolyte-resistant paint.

c. Polarity Determination. While polarity is generally indicated on a storage battery, the following method may be used if markings are unclear:

STEP 1. Connect leads to each terminal.

STEP 2. Hold free ends of the leads about one-half inch apart in a glass of water to which a little salt has been added.

STEP 3. Observe where bubbles form; bubbles will form on negative lead.

16.1.5 Dry Cells

Dry cell batteries are produced in various sizes and shapes, and in several capacities and voltages to accommodate their wide range of use. Ideally, they should be operated at temperatures between 60^{o} and 80^{o}F. At temperatures below 0^{o}F, they may fail to function or may function at reduced capacity unless warmed. The internal chemical action increases with ambient temperature rise; above 80^{o}F, dry batteries deteriorate rapidly even when not in use. Dry batteries require cool, dry storage. Warm or damp conditions will establish low-current short circuits across the terminals, thereby discharging the batteries. If practical, batteries should be stored under refrigeration at temperatures between 10^{o} and 35^{o}F. Normal shelf life for common type batteries in non-refrigerated storage in temperate zones is about 6 months. This type of battery should be tested under normal load. Open-circuit voltage tests are not trustworthy since exhausted dry batteries will usually indicate normal voltage (1.5 volts per cell).

All major dry cell manufacturers publish battery applications data. The range and scope of these data are beyond the intent of this handbook. Data pertaining to dry cell applications is readily available from the manufacturers.

16.2 POWER PANELS

Power supplied from generators and/or commercial sources are connected throughout communications buildings by means of branch circuits. Figure 16-2 depicts a typical power panel installed at the power service entrance.

16.2.1 Marking

Figure 16-3 shows a typical marking plan for an AC branching cabinet. The numerical designation is stamped on the outer edges of the panel. The nomenclature of the specific equipment served is stamped adjacent to the corresponding circuit breaker when designation cards are not furnished. Power supplied to the branching cabinet and plan item will be stamped on the top front of the branching cabinet and panel as shown.

16.2.2 Division of Circuit Loads

During initial installation of an electronics system, or when additional equipments are added, the primary power load division must be considered. The practice of adding equipments indiscriminately to a power panel can result in the following:

- o Inadequate power voltage regulation.

- o Circuit breakers dropping out when multiple equipments are used simultaneously.

- o Overheating of circuit breakers.

- o Ground loop problems. (When phases are unbalanced, neutral currents equal to the unbalance will flow.

The ideal wiring system is planned so that each wiring circuit will have the same ampere drain at all times. Since this can never be achieved, the circuiting is planned to divide the connected load as evenly as possible.

16.3 CONDUCTOR CONNECTORS

16.3.1 Solderless Pressure Connectors

Connectors of this type are used in both electrical and electronic applications.

16.3.2 Screw-on Connectors

The common screw-on connector (wire nut) consists of an insulated cap made of plastic, bakelite, porcelain, or nylon with a tapered spring-like metal thread inside. The tapered shape causes the conductors to be compressed tightly together as the connector is screwed on. Screw-on connectors may be used for connecting branch-circuit conductors, No. 14 or larger, and in certain instances may be used as fixture-splicing connectors.

Most screw-on connectors are designed for copper-to-copper wire connections. An exception is the type with a coated-steel coil spring, which may be used for aluminum-to-aluminum wire connections as well. No pressure connector, including the screw-on type, is approved or recommended for splicing aluminum and copper conductors together where the two different metals are to be in direct physical contact with each other. See figure 16-4 for typical installation procedures.

16.3.3 Heavy Duty Solderless Terminals

a. Compression Type. This type of connector is used for terminating conductors by cold swaging a connector of compatible alloy over the end of the conductor. Hand or hydraulic tools, with precision dies, apply pressure uniformly to the barrel of the connector.

This type of connector has long been in use in overhead and underground power transmission lines, secondary power distribution systems in aircraft and electric locomotive power feeder cables. They are well-known and accepted for their high reliability when properly selected and installed.

b. Mechanical Type. This type of connector is also used for terminating stranded wire. The difference is that the wire is placed in the barrel of the connector and a screw or saddle is forced down on the conductor. The high pressure wedge effect of the screw on the wire provides a positive interstrand contact. A standard wrench or screwdriver are the only tools required for installation.

Connectors marked with just the wire size should only be used with copper conductors. Connectors marked "AL" and the wire size should only be used with aluminum wire. Connectors marked "AL-CU" and the wire size may be safely used with either copper or aluminum.

It is recommended that preference be given to the aluminum compression type of connector for aluminum conductors.

Figure 16-5 shows some of the terminals available.

16.4 PLUGS AND RECEPTACLES

Plugs and receptacles are available in various configurations up to 400 amperes and 600 volts. Typical arrangements are shown in figure 16 6.

In an installation where various voltages, frequencies, or number of phases are used, a different receptacle type is required for each combination. All receptacles, except convenience outlets, should have an attached nameplate which states voltage, phase, and frequency.

All three-phase receptacles should be wired to produce clockwise phase rotation viewed from the front, and the nameplate should so state.

16.5 DEVICE AND JUNCTION BOXES

Device and junction boxes are used to assist in the pulling, splicing, and terminating of conductors and circuits, and for installation of switches and receptacles.

While a steel box is, quite naturally, of more durable construction than a non-metal box, its chief advantages are that it can be used with most wiring methods and that it is available in a wide range of sizes and types.

Many boxes are provided with clamps for securing non-metallic sheathed cable, non-metallic flexible tubing (loom), or armored cable. Clamps for such purposes are marked N for non-metallic sheathed cable, T for non-metallic flexible tubing, and A for metal-armored cable. Some clamps are marked NT for use with both previously mentioned non-metallic systems. It is generally more economical to use boxes provided with clamps than to use conduit boxes with separate cable connectors.

The main considerations for selecting box sizes for any type of wiring method are the number of conductors that will enter the box and whether or not switches, receptacles, studs, or clamps are to be installed in the box. Section 370-6 of the National Electrical Code (NEC) includes tables covering deep and shallow boxes. These tables will assist in determining the size of box to use for the number of conductors, devices, and fittings which they will contain.

16.6 WIRING METHODS

16.6.1 Rigid Metal Conduit

This is suitable for use in all atmospheric conditions and is discussed in Article 346 of the NEC.

16.6.2 Electrical Metallic Tubing (EMT)

This is suitable for use in either exposed or concealed work. Since it is not as mechanically strong as rigid metal conduit, it must be protected in installations where it is likely to be damaged. The NEC, Article 348, details requirements.

16.6.3 Flexible Metal Conduit

This method is used where flexibility is important; however, it cannot be used in wet locations unless the conductors are approved for this type of use. Article 350 of the NEC covers this method; chapter 2 contains information on fittings and installation techniques.

16.6.4 Liquid-Tight Flexible Metal Conduit

This type of conduit is not to be used as general purpose raceway. Its primary purpose is for the connection of motors and equipment where flexibility is required.

16.6.5 Surface Metal Raceways

Surface metal raceways include wiring troughs, gutters, and plug mold strips. These methods are covered under Article 352 in the NEC.

16.7 GROUNDING

Power systems must be adequately grounded to ensure safety to personnel and equipment. All pertinent requirements of the NEC must be carefully adhered to when power systems are being installed.

Table 16-1. Lead-Acid Battery Charging Rates in Amperes

CAPACITY OF BATTERY (10-hour rating)	START	FINISH
15AH	1.5	1.0
20AH	2.0	1.0
50AH	8.0	4.0
100AH	14.0	7.0
130AH	30.0	15.0
200AH	32.0	16.0
300AH	44.0	22.0

NOTE:

Charging rates materially lower than those specified on the battery nameplate are undesirable because of the longer time required for charging.

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Table 16-2. Data for Preparing Electrolyte

DESIRED ELEC-TROLYTE	WATER-ACID WEIGHT RATIO			WATER-ACID VOLUME RATIO		
	ACID SPECIFIC GRAVITY					
	1.350	1.400	1.835	1.350	1.400	1.835
1.10	1.98	2.33	5.21	2.67	3.26	9.55
1.11	1.71	2.03	4.06	2.31	2.84	8.45
1.12	1.51	1.81	4.24	2.04	2.53	7.79
1.13	1.34	1.62	3.89	1.81	2.27	7.15
1.14	1.19	1.45	3.58	1.61	2.02	6.57
1.15	1.05	1.30	3.28	1.42	1.82	6.02
1.16	0.95	1.18	3.07	1.28	1.65	5.63
1.17	0.85	1.07	2.86	1.15	1.50	5.25
1.18	0.75	0.96	2.65	1.01	1.35	4.87
1.19	0.67	0.87	2.49	0.90	1.22	4.57
1.20	0.59	0.78	2.31	0.80	1.09	4.24
1.21	0.52	0.70	2.18	0.70	0.98	4.00
1.22	0.46	0.64	2.05	0.62	0.90	3.76
1.23	0.41	0.58	1.94	0.55	0.81	3.56
1.24	0.36	0.52	1.83	0.49	0.73	3.36
1.25	0.31	0.46	1.73	0.42	0.64	3.17
1.26	0.26	0.42	1.64	0.35	0.59	3.01
1.27	0.22	0.37	1.55	0.30	0.52	2.84
1.28	0.18	0.32	1.47	0.24	0.45	2.70
1.29	0.15	0.29	1.40	0.20	0.41	2.57
1.30	0.12	0.25	1.33	0.16	0.35	2.44
1.31	0.09	0.22	1.27	0.12	0.31	2.33
1.32	0.06	0.18	1.20	0.08	0.25	2.20
1.33	0.03	0.15	1.15	0.04	0.21	2.11
2.34	0	0.12	1.09	0	0.17	2.00
2.35	-	0.09	1.04	-	0.13	1.96

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Table 16-3. Electrolyte Specific Gravity Temperature Correction

TEMPERATURE °F	TEMPERATURE °C	CORRECTION FACTOR	TEMPERATURE °F	TEMPERATURE °C	CORRECTION FACTOR	TEMPERATURE °F	TEMPERATURE °C	CORRECTION FACTOR
32	0.0	-0.015	62	16.7	-0.005	92	33.4	+0.005
35	1.7	-0.014	65	18.4	-0.004	95	35.0	+0.006
38	3.4	-0.013	68	20.0	-0.003	98	36.7	+0.007
41	5.0	-0.012	71	21.7	-0.002	101	38.4	+0.008
44	6.7	-0.011	74	23.4	-0.001	104	40.0	+0.009
47	8.4	-0.010	77	25.0	0.000	107	41.7	+0.010
50	10.0	-0.009	80	26.7	+0.001	110	43.4	+0.011
53	11.7	-0.008	83	28.4	+0.002	113	45.0	+0.012
56	13.4	-0.007	86	30.0	+0.003	116	46.7	+0.013
59	15.0	-0.006	89	31.7	+0.004	119	48.4	+0.014

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Table 16-4. Nickel-Cadmium Battery Charging Rates in Amperes

BATTERY CAPACITY (5-hour rate)	CHARGING RATE	BATTERY CAPACITY (5-hour rate)	CHARGING RATE	BATTERY CAPACITY (5-hour rate)	CHARGING RATE
0.8 AH	0.2	25 AH	5.0	3.6 AH	0.7
2.0 AH	0.4	40 AH	8.0	5.7 AH	1.2
4.0 AH	0.8	45 AH	9.0	11.0 AH	2.5
4.7 AH	1.0	60 AH	12.0	22.0 AH	5.0
6.0 AH	1.2	81 AH	16.0	34.0 AH	7.0
7.5 AH	1.5	125 AH	25.0	35.0 AH	8.0
13.0 AH	2.5	171 AH	35.0	60.0 AH	13.0
15.0 AH	3.0	200 AH	40.0	70.0 AH	16.0
20.0 AH	4.0	280 AH	56.0		

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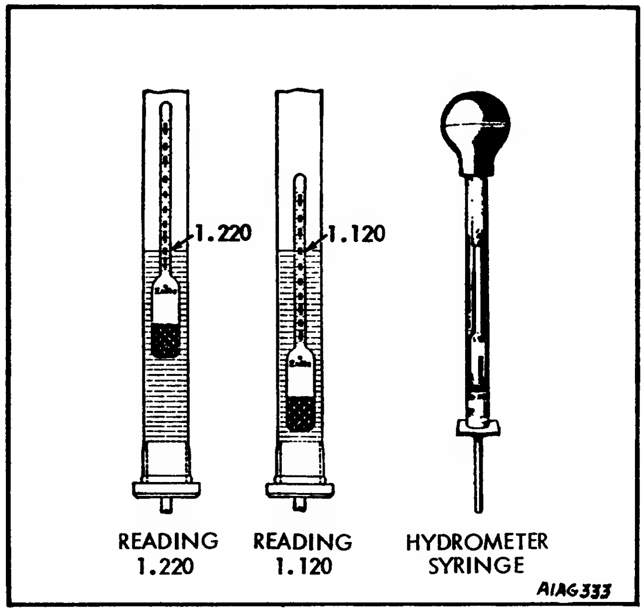

Figure 16-1. Reading a Hydrometer

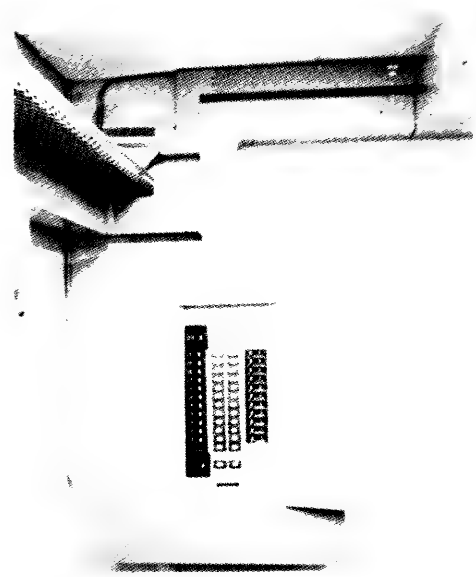

Figure 16-2. Typical Power Panel Installation

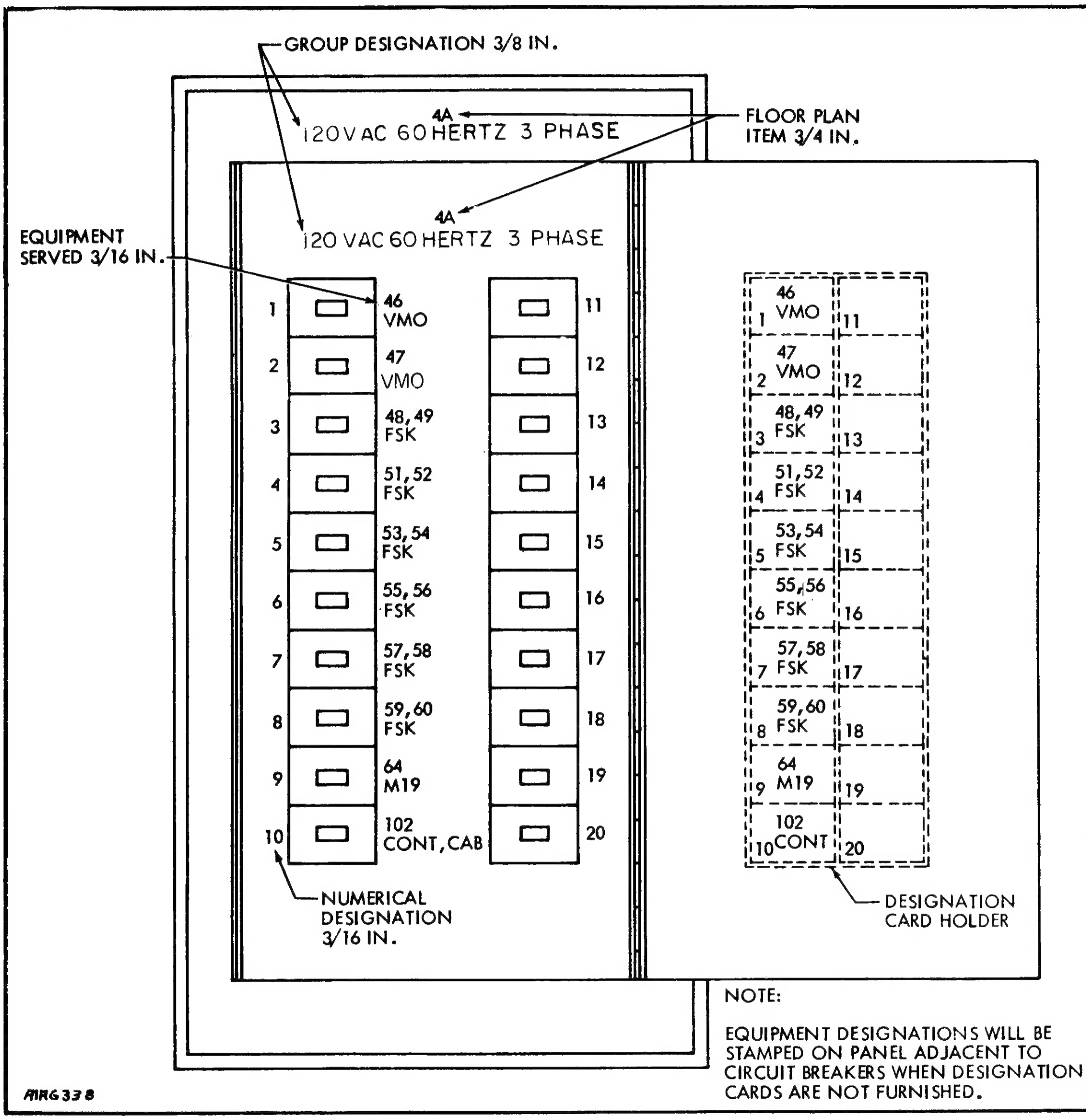

Figure 16-3. Typical Marking of a Power Panel Board

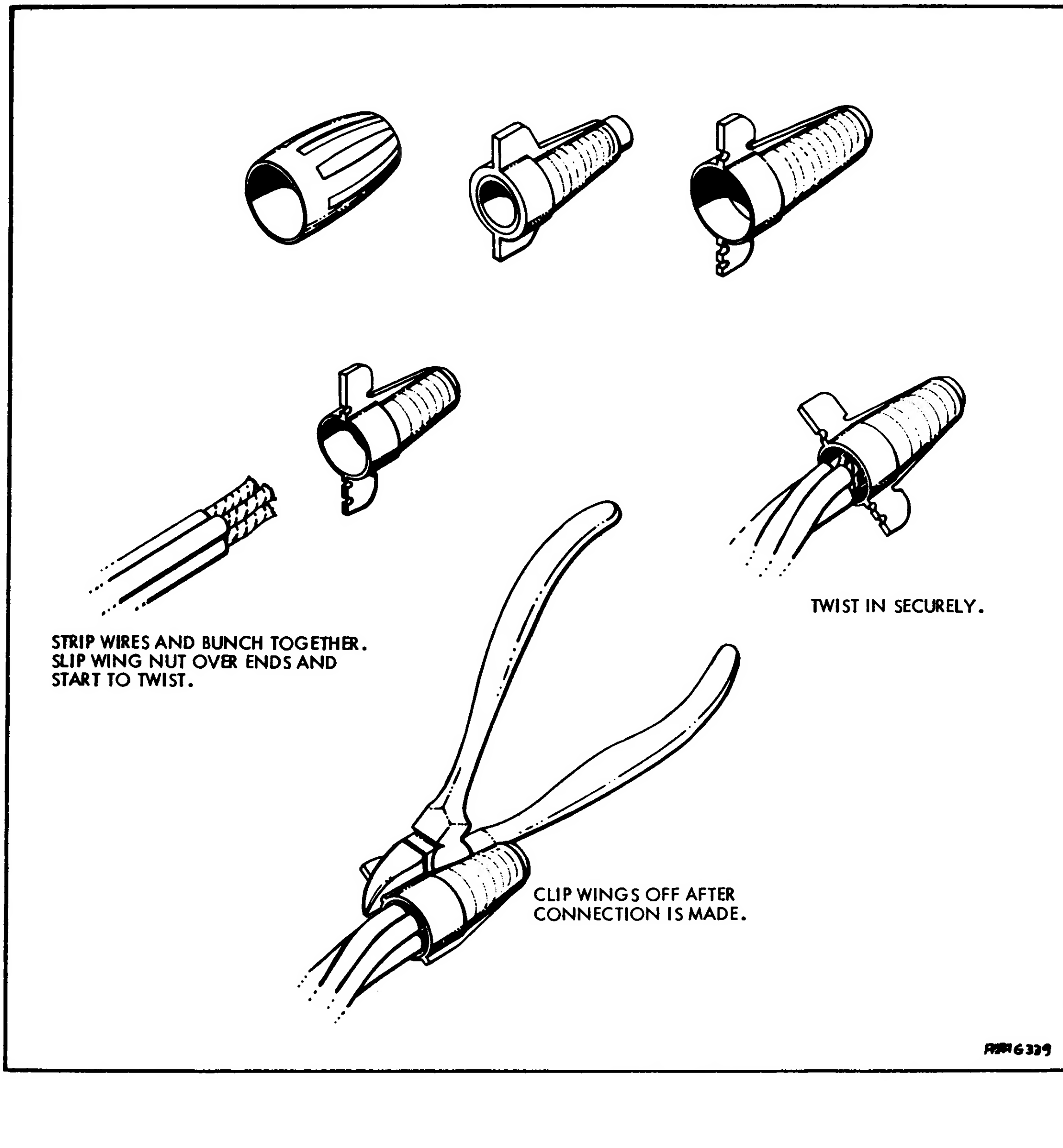

Figure 16-4. Screw-In Connectors and Procedure for Installation

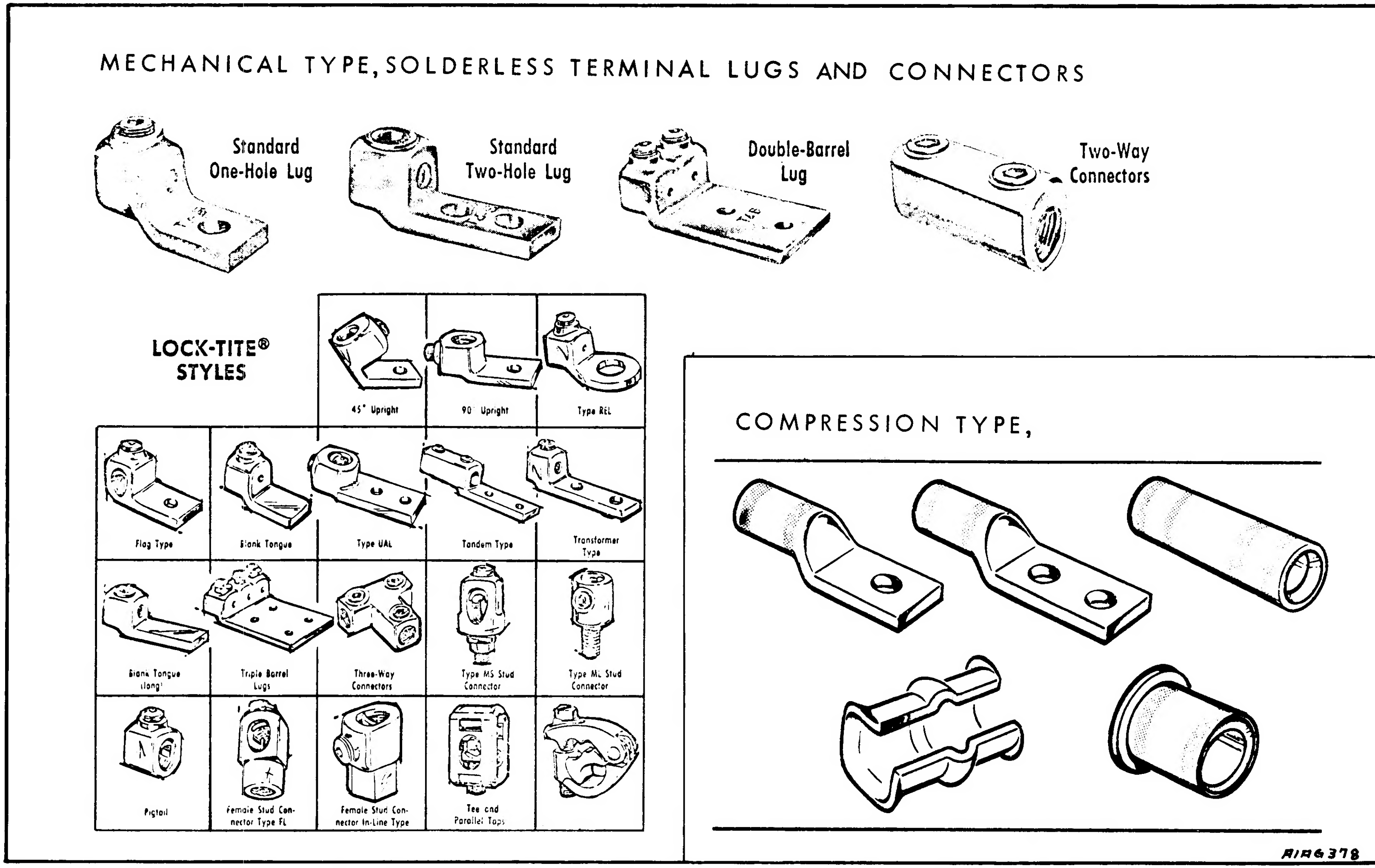

Figure 16-5. Pressure-Type Solderless Terminals

# POLES # WIRES	RECEPT CATALOG NUMBER	RECEPT FACE VIEW	PLUG FACE VIEW	# POLES # WIRES	RECEPT CATALOG NUMBER	RECEPT FACE VIEW	PLUG FACE VIEW
2 POLE 2 WIRE	250 V 20 Ampere **HUBBELL #5552B 7058**	W	W	3 POLE 4 WIRE GROUNDED	250 V 20 Ampere **HUBBELL #20403** 21415	G	G
2 POLE 2 WIRE	250 V 30 Ampere **HUBBELL #7438 7436**	W	W				
2 POLE 2 WIRE	**RUSS & STOLL #1752 140**	W	W	3 POLE 3 WIRE	125/250 V 20 Ampere **HUBBELL** # 7310	G	G
2 POLE 3 WIRE GROUNDING	125 V 15 Ampere **HUBBELL #5262** 5266	W G	W G	3 POLE 3 WIRE	125/250 V 30 Ampere **HUBBELL** 9350 9337	G	G
3 POLE 3 WIRE	125 V 15 Ampere **HUBBELL #7580** 7572	W G	W G	4 POLE 4 WIRE	250 V. 20 Ampere **HUBBELL #7410BG 7411G**	G	G
3 POLE 3 WIRE	125/250 V 20 Ampere **HUBBELL #6810G 7089G**	G W	G W	4 POLE 4 WIRE	120/208 V 20 Ampere **HUBBELL #7250G 7251**	G	G
3 POLE 3 WIRE	125 V 15 Ampere **HUBBELL** # 7580 **7763**	G W	G W				
2 POLE 3 WIRE GROUNDING	**HUBBELL #5661 5664**	G W	G W	4 POLE 4 WIRE	3Ø Y 60 Ampere **HUBBELL #7301 7303**	W G	W G

NOTES:

W - INDICATES GROUNDED CIRCUIT BLADE OR FEMALE CONTACT; IDENTIFIED CIRCUIT OR NEUTRAL FOR AC CIRCUITS AND NEGATIVE POLE FOR DC CIRCUITS.

G - INDICATES EQUIPMENT GROUND BLADE OR FEMALE CONTACT; BLADE IS GENERALLY MARKED "G" FOR GROUND OR "GR" FOR GROUNDING.

TOP NUMBER REFERS TO PLUG; BOTTOM NUMBER REFERS TO RECEPTACLE.

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Figure 16-6. Arrangements of Power Plugs and Receptacles